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Trajectories of Inner and Outer Heliospheric Spacecraft

Predicted Through 1999

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Preface

The objective of this report is to present in tabular and graphical form information on the trajectories of the international fleet of spacecraft that will be probing the far reaches of the heliosphere during the 1990s. In particular, the following spacecraft are addressed.

Pioneer 10 and 11
Pioneer Venus Orbiter (PVO)
Voyager 1 and 2
Galileo
Ulysses
Suisei, Sakigake
Giotto
International Cometary Explorer (ICE)
Interplanetary Monitoring Platform 8 (IMP 8)

Yearly resolution listings of position information in inertial space are given for the Pioneer and Voyager spacecraft from the times of their launches in the 1970s. Monthly resolution listings of parameters relative to a fixed Earth-Sun line are given for the inner-heliosphere spacecraft. Algorithms are given for the inertial space positions of Earth (IMP 8) and Venus (PVO) and for the Earth-Sun-Venus angle.

One series of plots shows the radial distances, latitudes, and longitudes of the Pioneers and Voyagers. The longitude plot of this series also shows the excursion of the Earth in ecliptic longitude each year. A Ulysses-dedicated plot is next given, showing at monthly resolution the latitude and radial distance excursion over the 1990s. Then a series of four plots, each covering successive three-year intervals, shows the Earth-Sun-spacecraft angles for all the spacecraft addressed in the report. Finally, two plots show the ICE and Sakigake trajectories in fixed Sun-Earth line systems, from their launches to their 2014 (ICE) and 1992 Earth vicinity returns, and one cartoon shows the Ulysses spacecraft from 1990 launch through 1992 Jupiter encounter to the 1994 and 1995 south and north solar pole passes.

The solar ecliptic inertial coordinate system is used in this report. In this system, the Z axis is normal to the ecliptic plane and the X axis is towards the first point of Aries (from Sun to Earth on the vernal equinox). In addition, heliographic latitudes are also used, which are latitudes defined relative to the solar equatorial plane and solar spin vector.

This report is a follow-up to a 1986 National Space Science Data Center (NSSDC) report that listed and plotted heliospheric spacecraft trajectory information for the 1970s and 1980s. That report was *Trajectories of Pioneers 6-11, Helios A and B, and Voyagers 1 and 2* (NSSDC report 86-03, 1986) and is available, as are additional copies of this report, by request to the NSSDC Coordinated Request and User Support Office (301-286-6695; NCF::REQUEST).

On-Line Files

In addition to the plots and listings of the report mentioned above, NSSDC also makes available on-line files with daily resolution of 1989-1999 trajectory information (Cartesian) for those users for whom the lower resolution information of this report, or the coordinates used herein, are unsuitable. One of the files is an executable code; the interface offered to users enables the specification of the spacecraft, the time resolution of the output listing, and the parameters to be listed (available parameters are radial distance, solar ecliptic latitude and longitude, and heliographic latitude and longitude).

The on-line files were created by the several NSSDC codes from the ephemeris tapes generated at the Flight Dynamics Branch, Goddard Space Flight Center (GSFC), by running the GTDS code against sets of orbital elements for the various spacecraft involved.

The files are presently held in an ANONYMOUS account on an NSSDC VAX. They may be copied to individual VAX accounts using the command

```
COPY NSSDCA::ANON_DIR:[ACTIVE.HELIO]FILE.NAME FILE.NAME
```

An annotated list of precomputed files and a brief description of the executable code (executable from DECnet nodes only) are available in a file named JHK.RP. This file should be copied first and read via

```
COPY NSSDCA::ANON_DIR:[ACTIVE.HELIO]JHK.RP FILE.LIST.
```

Those in nodes other than DECnet may access files via FTP as follows:

At the prompt, type `FTP NSSDCA.GSFC.NASA.GOV`
At the next prompt, type `ANONYMOUS`
At the message PASSWORD `(NSSDCA.GSFC.NASA.GOV:ANONYMOUS):`, press return.
At the next prompt, type `GET ANON_DIR:[000000.ACTIVE.HELIO]JHK.RP FILE.LIST`
(There are six zeros in this response.)
At the following prompt, type `QUIT`

NSSDC offers many data and services via its no-password NODIS account, which is accessible over DECnet via `SET HOST NSSDCA, USERNAME=NSSDC`. It is probable that after some time the deep space trajectory files described herein and now held in the ANONYMOUS account will be moved to the NODIS account.

Acknowledgment

The authors appreciate the untiring efforts of Frank Ferrier for providing the final versions of the GTDS ephemeris tapes (IBM binary). John Vanderpool enabled VAX ASCII versions of them. The Jet Propulsion Laboratory has been the main source for the orbital element set collection used.

List of Tables

List of Figures

Tables

Table 1: Radial Distance, Heliographic Latitude, and Ecliptic Longitude

		Pioneer 10			Pioneer 11			Voyager 1			Voyager 2			Ulysses		
YY	DOY	AU	HLAT	ELON	AU	HLAT	ELON	AU	HLAT	ELON	AU	HLAT	ELON	AU	HLAT	ELON
73	1	3.4	3.1	291.5												
74	1	5.1	7.0	319.0	3.2	4.2	323.5									
75	1	6.6	8.5	7.5	5.1	6.1	354.5									
76	1	9.0	7.9	29.0	3.7	15.5	47.5									
77	1	11.8	7.3	41.5	4.5	11.3	107.0									
78	1	15.1	6.6	48.5	6.5	2.2	139.5	2.0	1.0	68.5	2.0	5.9	68.5			
79	1	17.8	5.9	54.5	8.4	-3.1	157.5	5.0	-5.0	122.5	4.6	-3.9	125.5			
80	1	21.1	5.4	59.0	9.2	-3.1	171.5	7.0	-5.5	160.5	6.0	-5.9	154.5			
81	1	23.8	4.8	60.0	9.7	3.6	189.5	9.6	-2.8	182.5	8.1	-4.8	179.5			
82	1	26.4	4.6	63.0	11.1	8.6	209.0	12.0	9.4	199.5	9.6	-3.7	198.5			
83	1	28.8	4.3	65.0	12.0	11.6	224.5	15.0	17.6	211.5	11.2	-2.4	221.5			
84	1	32.0	4.0	67.5	15.1	13.8	234.5	18.3	22.1	220.0	13.2	-10.0	238.5			
85	1	34.4	3.8	68.5	17.6	15.1	242.0	22.1	25.0	225.5	16.2	-0.1	248.5			
86	1	37.2	3.8	70.0	20.0	15.9	249.0	25.8	26.6	229.5	19.2	0.5	256.5			
87	1	40.0	3.6	71.0	22.5	16.5	253.0	29.0	28.1	233.5	22.1	1.9	264.5			
88	1	42.8	3.6	72.0	25.2	16.7	257.0	33.2	29.2	236.5	25.6	3.1	271.5			
89	1	45.4	3.5	71.8	27.4	16.9	260.9	36.3	30.1	240.2	28.0	3.6	278.6			
90	1	48.1	3.5	72.4	29.8	17.0	263.4	39.9	30.7	242.0	31.1	2.4	281.1			
91	1	50.7	3.4	72.9	32.3	17.1	265.5	43.6	31.3	243.6	33.6	-1.7	281.9	1.59	-0.8	98.5
92	1	53.4	3.3	73.4	34.8	17.2	267.3	47.2	31.7	244.9	36.3	-5.2	282.6	5.09	-5.9	155.7
93	1	56.0	3.3	73.9	37.3	17.3	268.8	50.8	32.1	246.0	39.0	-8.3	283.3	5.07	-22.8	160.6
94	1	58.7	3.2	74.3	39.8	17.3	270.2	54.5	32.4	247.0	41.8	-10.9	283.8	3.84	-48.4	167.1
	255													2.32	-80.2	211.3
95	1	61.3	3.2	74.7	42.2	17.3	271.4	58.1	32.6	247.8	44.8	-13.1	284.3	1.57	-45.0	323.3
	213													2.01	80.2	32.4
96	1	63.9	3.1	75.0	44.7	17.4	272.4	61.7	32.8	248.6	47.7	-15.1	284.8	3.05	53.4	138.0
97	1	66.5	3.1	75.3	47.2	17.4	273.4	65.3	33.0	249.3	50.7	-16.9	285.2	4.71	19.1	152.0
98	1	69.1	3.0	75.6	49.6	17.4	274.2	69.0	33.2	249.9	53.7	-18.4	285.6	5.37	-0.8	156.2
99	1	71.7	3.0	75.9	52.0	17.4	275.0	72.6	33.4	250.4	56.7	-19.8	285.9	5.21	-18.9	159.7
99	335	74.0	3.0	76.1	54.3	17.4	275.7	75.9	33.5	250.9	59.7	-21.1	286.2	4.30	-39.5	164.4

Table 2: Radial Distance and Ecliptic Plane Earth-Sun-Probe Angle

		ICE		Suisei		Sakigake		Galileo		Ulysses	
YY	DOY	AU	ESP	AU	ESP	AU	ESP	AU	ESP	AU	ESP
89	1	0.93	61.5	0.81	319.1	0.89	226.8				
89	32	0.93	64.9	0.71	335.6	0.95	229.6				
89	60	0.94	67.7	0.68	359.8	0.99	228.9				
89	91	0.96	69.9	0.75	23.3	1.01	226.3				
89	121	0.99	70.8	0.86	34.7	1.01	223.9				
89	152	1.02	70.6	0.96	37.6	0.97	223.2				
89	182	1.03	69.8	1.01	36.3	0.92	225.7				
89	213	1.03	68.6	1.00	33.7	0.86	232.8				
89	244	1.02	67.7	0.95	32.8	0.82	244.5				
89	274	1.00	67.8	0.85	36.8	0.82	257.8				
89	305	0.97	68.7	0.74	50.2	0.86	268.9	0.99	358.1		
89	335	0.94	70.9	0.68	74.4	0.92	274.7	0.96	355.8		
90	1	0.93	74.1	0.72	100.5	0.97	275.9	0.87	357.2		
90	32	0.93	77.6	0.83	114.8	1.01	273.8	0.75	7.6		
90	60	0.94	80.1	0.93	118.2	1.01	270.8	0.70	29.7		
90	91	0.97	81.7	1.00	116.4	0.99	268.2	0.79	52.2		
90	121	1.00	81.9	1.01	112.8	0.95	267.9	0.95	59.9		
90	152	1.02	81.2	0.98	110.2	0.89	271.9	1.09	57.6		
90	182	1.03	80.1	0.89	111.9	0.84	280.8	1.20	50.2		
90	213	1.03	79.0	0.78	121.9	0.82	294.0	1.26	39.7		
90	244	1.01	78.5	0.69	144.5	0.84	307.5	1.27	28.3		
90	274	0.99	78.9	0.69	172.8	0.89	316.9	1.24	17.3		
90	305	0.96	80.6	0.79	193.3	0.95	321.3	1.15	7.3	1.04	8.1
90	335	0.94	83.4	0.90	200.9	0.99	321.4	1.02	1.4	1.27	9.6
91	1	0.93	87.0	0.98	200.5	1.01	318.8	0.91	5.8	1.59	359.2
91	32	0.93	90.3	1.01	196.3	1.01	315.5	0.94	15.8	1.93	341.2
91	60	0.95	92.2	0.99	192.2	0.98	313.4	1.06	19.1	2.24	321.3
91	91	0.98	93.2	0.92	190.7	0.92	314.2	1.25	14.0	2.57	297.3
91	121	1.01	92.8	0.82	196.0	0.87	319.6	1.45	2.7	2.89	272.9
91	152	1.03	91.6	0.71	213.3	0.82	330.3	1.63	347.0	3.20	247.1
91	182	1.03	90.4	0.68	240.9	0.82	343.5	1.79	329.7	3.49	222.1
91	213	1.02	89.4	0.75	266.3	0.86	355.7	1.93	310.2	3.78	195.7
91	244	1.00	89.2	0.87	279.1	0.92	3.3	2.05	289.4	4.06	169.0
91	274	0.98	90.3	0.96	282.3	0.97	6.2	2.14	268.4	4.33	142.6
91	305	0.95	92.6	1.01	280.3	1.00	5.7	2.21	245.3	4.59	114.4
91	335	0.93	96.0	1.00	276.6	1.01	3.3	2.25	222.3	4.84	86.4

Table 2: Radial Distance and Ecliptic Plane Earth-Sun-Probe Angle (continued)

		ICE		Suisei		Sakigake		Galileo		Ulysses		Giotto	
YY	DOY	AU	ESP	AU	ESP	AU	ESP	AU	ESP	AU	ESP	AU	ESP
92	1	0.93	99.7	0.95	274.0	0.99	0.6	2.27	197.7	5.09	56.7	1.16	298.5
92	32	0.94	102.7	0.85	276.4	0.95	1.3	2.26	172.7	5.33	26.5	1.16	290.2
92	61	0.96	104.2	0.74	287.9	0.93	4.5	2.24	149.4	5.40	357.2	1.15	282.4
92	92	0.99	104.4	0.68	312.6	0.93	9.1	2.19	125.2	5.39	326.1	1.12	275.4
92	122	1.02	103.5	0.72	338.5	0.97	12.5	2.12	102.7	5.38	296.6	1.09	270.5
92	153	1.03	102.0	0.83	354.4	1.02	13.7	2.02	80.6	5.36	266.7	1.05	268.0
92	183	1.03	100.6	0.93	359.8	1.07	12.3	1.90	60.6	5.34	238.2	1.02	268.1
92	214	1.02	99.8	1.00	359.6	1.11	8.8	1.75	41.5	5.31	209.0	1.00	270.1
92	245	0.99	100.3	1.03	357.9	1.13	4.0	1.58	24.7	5.27	179.9	1.00	272.6
92	275	0.97	101.9	1.03	355.5	1.13	358.4	1.40	11.1	5.23	151.4	1.02	273.9
92	306	0.94	104.9	1.00	352.9	1.11	352.7	1.20	1.5	5.18	121.4	1.06	272.9
92	336	0.93	108.7	0.95	352.3	1.07	347.8	1.02	359.2	5.13	91.8	1.09	269.5
93	1	0.93	112.4	0.88	355.4	1.02	344.6	1.02	6.5	5.07	60.8		
93	32	0.95	114.9	0.82	4.2	0.97	344.2	1.20	7.5	5.00	29.4		
93	60	0.97	115.8	0.80	16.2	0.93	346.5	1.44	359.6	4.94	1.2		
93	91	1.00	115.3	0.82	29.4	0.93	350.9	1.72	344.1	4.86	330.2		
93	121	1.02	113.9	0.89	38.1	0.95	355.4	1.99	325.4	4.77	300.8		
93	152	1.03	112.2	0.96	42.0	0.99	358.1	2.26	303.9	4.68	271.0		
93	182	1.03	110.9	1.01	42.1	1.04	357.7	2.51	281.8	4.58	242.7		
93	213	1.01	110.5	1.03	40.4	1.07	354.9	2.74	258.1	4.48	213.8		
93	244	0.98	111.4	1.02	38.2	1.08	351.1	2.97	233.4	4.36	184.9		
93	274	0.96	113.7	0.98	37.2	1.06	347.6	3.18	208.6	4.24	156.7		
93	305	0.93	117.4	0.92	39.2	1.01	345.2	3.37	182.0	4.11	127.2		
93	335	0.93	121.4	0.85	45.4	0.96	345.0	3.55	155.3	3.98	98.1		
94	1	0.94	124.9	0.80	57.0	0.90	348.3	3.73	126.9	3.84	67.6		
94	32	0.96	126.9	0.81	70.8	0.87	355.2	3.89	97.9	3.68	37.0		
94	60	0.99	127.2	0.85	80.6	0.87	2.7	4.03	71.5	3.54	9.6		
94	91	1.01	126.1	0.92	86.0	0.91	9.6	4.17	42.4	3.36	339.9		
94	121	1.03	124.3	0.99	87.0	0.96	13.0	4.30	14.8	3.19	312.2		
94	152	1.03	122.5	1.02	85.3	1.02	13.2	4.42	346.6	3.00	284.9		
94	182	1.02	121.3	1.03	82.9	1.06	11.1	4.53	319.7	2.81	260.4		
94	213	1.00	121.2	1.01	81.1	1.08	7.6	4.64	292.1	2.61	238.2		
94	244	0.97	122.8	0.95	81.9	1.07	4.0	4.74	264.4	2.39	223.4		
94	274	0.95	125.7	0.88	86.6	1.04	1.1	4.82	237.3	2.18	227.1		
94	305	0.93	129.8	0.82	96.6	0.99	359.3	4.90	208.6	1.96	246.3		
94	335	0.93	133.9	0.80	110.1	0.93	1.3	4.97	180.3	1.76	242.9		

Table 2: Radial Distance and Ecliptic Plane Earth-Sun-Probe Angle (continued)

		ICE		Suisei		Sakigake		Galileo		Ulysses	
YY	DOY	AU	ESP	AU	ESP	AU	ESP	AU	ESP	AU	ESP
95	1	0.94	137.2	0.83	123.2	0.86	6.9	5.04	150.4	1.57	224.0
95	32	0.97	138.6	0.89	131.0	0.83	16.5	5.10	120.3	1.42	199.5
95	60	1.00	138.2	0.96	133.1	0.85	26.0	5.14	93.0	1.35	175.6
95	91	1.02	136.6	1.01	131.6	0.90	33.8	5.19	63.0	1.36	149.1
95	121	1.03	134.5	1.03	128.6	0.96	37.3	5.22	34.6	1.45	124.4
95	152	1.03	132.6	1.02	125.6	1.01	37.4	5.25	5.8	1.61	101.6
95	182	1.02	131.7	0.98	124.6	1.05	35.3	5.27	338.3	1.80	85.2
95	213	0.99	132.1	0.92	127.1	1.06	32.3	5.29	310.2	2.01	83.1
95	244	0.96	134.3	0.85	135.1	1.03	29.8	5.30	282.1	2.23	101.4
95	274	0.94	137.9	0.80	147.9	0.99	28.8	5.30	254.6	2.44	104.1
95	305	0.93	142.4	0.80	163.0	0.99	359.7	5.29	225.6	2.65	88.4
95	335	0.93	146.5	0.85	174.3	0.95	1.8	5.28	197.2	2.85	65.9
96	1	0.95	149.3	0.93	179.5	0.93	5.4	5.27	168.3	3.05	39.0
96	32	0.95	117.5	0.99	179.2	0.95	8.8	5.27	136.5	3.23	10.3
96	61	0.98	120.3	1.02	176.2	0.98	10.5	5.26	109.4	3.40	342.8
96	92	1.01	117.6	1.03	172.1	1.03	9.7	5.25	80.4	3.57	313.1
96	122	1.03	117.1	1.01	169.2	1.07	7.1	5.24	53.1	3.72	284.6
96	153	1.03	114.4	0.95	169.2	1.10	2.9	5.23	25.4	3.88	255.5
96	183	1.03	114.0	0.88	173.8	1.12	358.3	5.22	359.1	4.01	227.7
96	214	1.01	112.8	0.82	184.8	1.11	353.6	5.21	332.2	4.15	199.1
96	245	0.98	113.8	0.80	200.2	1.09	349.5	5.19	305.3	4.28	170.3
96	275	0.95	117.3	0.83	214.4	1.05	346.7	5.18	279.1	4.39	142.2
96	306	0.93	120.0	0.89	223.6	1.00	345.5	5.17	251.3	4.51	112.4
96	336	0.93	125.2	0.96	226.4	0.96	346.4	5.16	224.0	4.61	83.1
97	1	0.94	127.5	1.01	224.6	0.94	349.3	5.15	195.1	4.71	52.1
97	32	0.96	129.4	1.03	220.5	0.94	353.0	5.14	166.1	4.80	20.9
97	60	0.99	132.5	1.02	216.6	0.96	355.5	5.13	140.1	4.87	352.7
97	91	1.01	128.2	0.98	213.9	1.00	356.1	5.12	111.1	4.95	321.7
97	121	1.03	127.3	0.92	215.2	1.05	354.5	5.11	84.0	5.02	292.3
97	152	1.03	124.5	0.85	222.3	1.09	351.2	5.10	56.3	5.09	262.4
97	182	1.02	124.3	0.80	235.2	1.11	346.9	5.09	30.2	5.15	234.0
97	213	1.00	123.5	0.80	251.2	1.12	342.1	5.08	3.4	5.20	204.9
97	244	0.97	125.1	0.86	264.1	1.11	337.5	5.07	336.6	5.25	175.7
97	274	0.94	129.3	0.93	270.6	1.08	333.7	5.06	310.6	5.29	147.2
97	305	0.93	132.5	0.99	271.8	1.03	331.2	5.05	282.9	5.32	117.3
97	335	0.93	137.7	1.03	269.4	0.99	330.6	5.04	255.7	5.35	87.6

Table 2: Radial Distance and Ecliptic Plane Earth-Sun-Probe Angle (continued)

		ICE		Suisei		Sakigake		Galileo		Ulysses	
YY	DOY	AU	ESP	AU	ESP	AU	ESP	AU	ESP	AU	ESP
98	1	0.97	172.6	1.03	265.2	0.95	332.2	5.02	229.7	5.37	56.5
98	32	1.00	172.0	1.00	261.4	0.93	335.5	5.02	200.8	5.39	25.1
98	60	1.02	170.1	0.95	260.1	0.95	338.6	5.01	174.7	5.40	356.8
98	91	1.03	167.3	0.88	263.2	0.98	340.5	5.00	146.1	5.41	325.7
98	121	1.03	164.9	0.82	272.3	1.03	340.3	4.99	119.0	5.41	296.2
98	152	1.01	163.4	0.80	286.9	1.07	338.0	4.99	91.5	5.40	266.2
98	182	0.99	163.8	0.82	301.3	1.10	334.4	4.98	65.5	5.39	237.7
98	213	0.96	166.1	0.89	311.5	1.12	329.8	4.98	38.8	5.38	208.5
98	244	0.94	170.2	0.96	315.8	1.12	325.0	4.97	12.1	5.36	179.3
98	274	0.93	175.2	1.01	315.8	1.09	320.6	4.97	346.1	5.33	150.8
98	305	0.93	180.0	1.03	313.2	1.06	317.1	4.96	318.7	5.29	120.9
98	335	0.95	183.1	1.02	309.7	1.01	315.1	4.96	291.5	5.25	91.3
99	1	0.98	183.9	0.98	307.1	0.97	315.4	4.96	262.9	5.21	60.2
99	32	1.01	182.6	0.91	307.6	0.94	317.7	4.96	234.0	5.16	28.8
99	60	1.03	180.3	0.85	312.8	0.94	321.0	4.95	207.9	5.10	0.5
99	91	1.03	177.3	0.80	324.4	0.96	324.0	4.95	179.4	5.04	329.4
99	121	1.03	175.0	0.80	338.6	1.00	325.3	4.95	152.3	4.97	300.0
99	152	1.01	174.0	0.85	350.9	1.05	324.3	4.95	125.0	4.89	270.2
99	182	0.98	174.9	0.92	357.6	1.09	321.5	4.95	98.9	4.81	241.8
99	213	0.95	177.8	0.99	359.7	1.11	317.4	4.95	72.3	4.72	212.7
99	244	0.93	182.6	1.03	358.7	1.12	312.6	4.96	45.7	4.63	183.8
99	274	0.93	187.7	1.03	356.2	1.11	307.8	4.96	19.6	4.53	155.5
99	305	0.94	192.2	1.00	353.8	1.08	303.4	4.96	352.2	4.42	125.7
99	335	0.96	194.7	0.94	353.6	1.03	300.3	4.96	325.0	4.30	96.4

Earth-Sun-Pioneer/Venus Angle

EARTH: Ecliptic Longitude of Earth on Every 1 Jan = 99.8 deg (+/- 0.5)

Longitude Increases by 0.9856 Deg/Day

Longitude on Any Day Number (DDD) = 99.8 + DDD × 0.9856

VENUS: Ecliptic Longitude of Venus on 1 Jan 89 = 225.4 Deg

Longitude Increases by 1.602 Deg/Day !!! Day is Earth Day

Longitude on YY, DDD = 225.4 + [365.25 × (YY - 89) + DDD] × 1.602

Earth-Sun-Venus Angle, ESV:

125.6 + 585.1 × (YY - 89) + 0.6164 × DDD

Figures

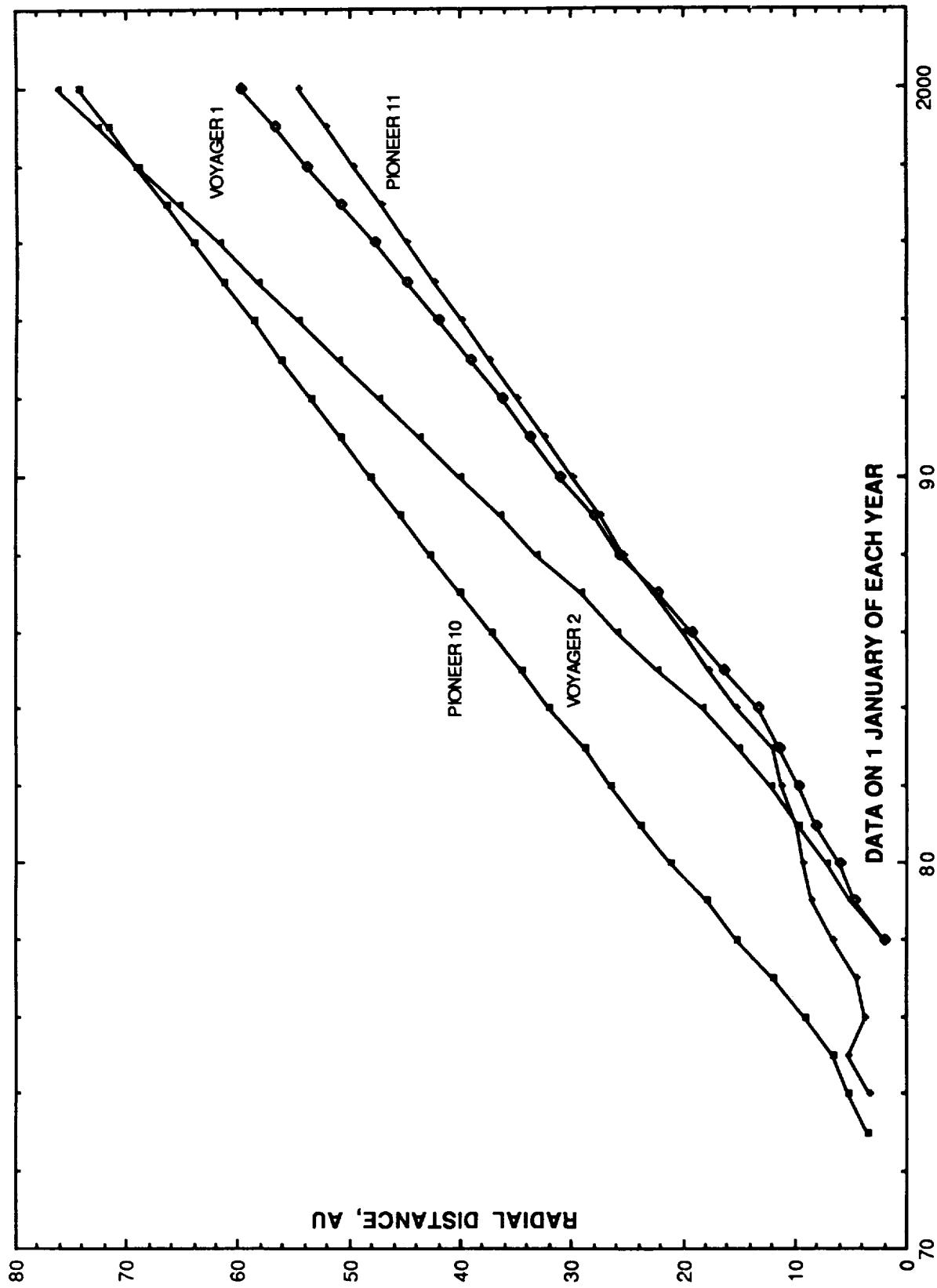


Figure 1. Radial Distances of Pioneer 10, Pioneer 11, Voyager 1, and Voyager 2

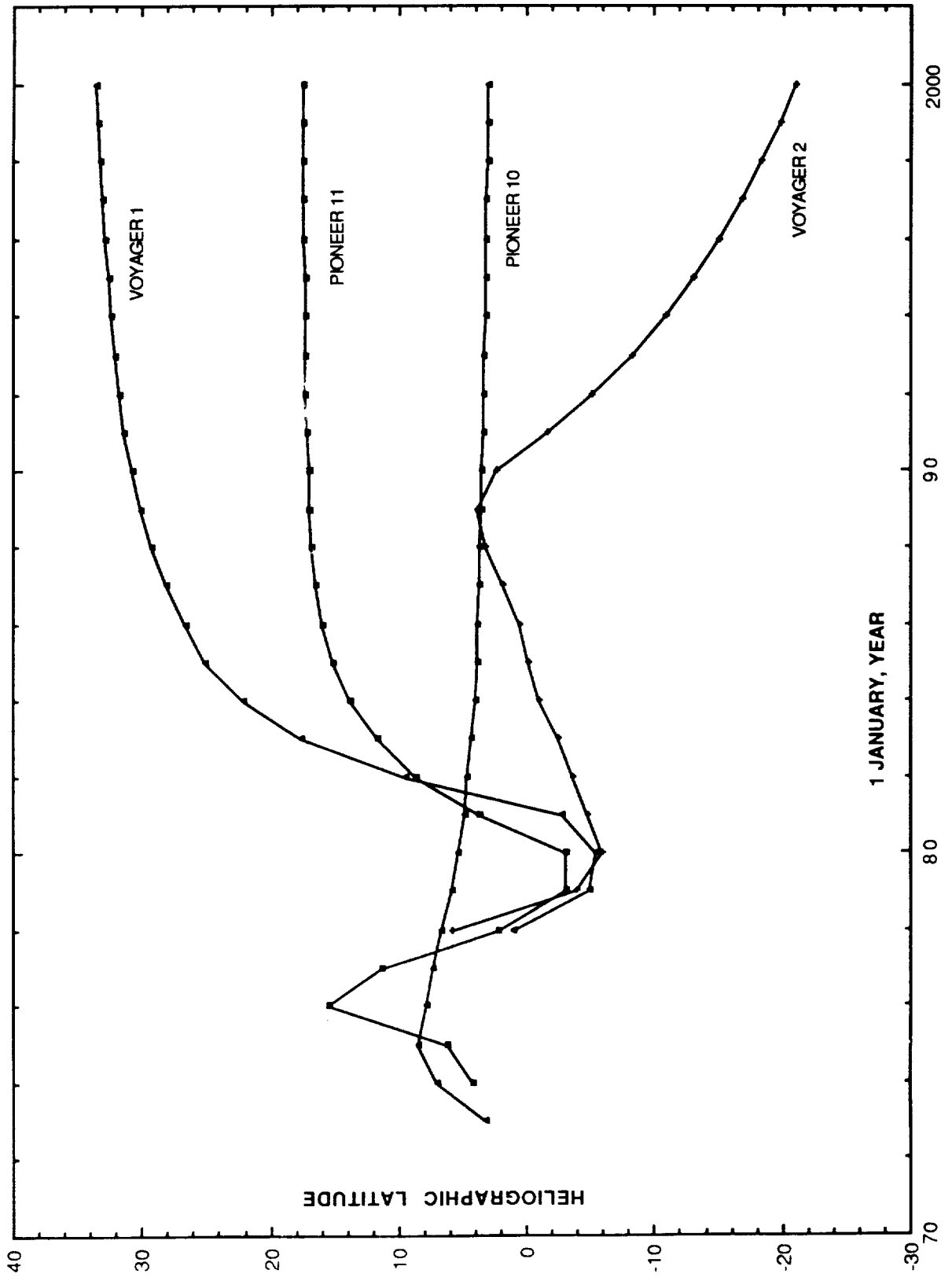


Figure 2. Heliographic Latitudes on Pioneer 10, Pioneer 11, Voyager 1, and Voyager 2

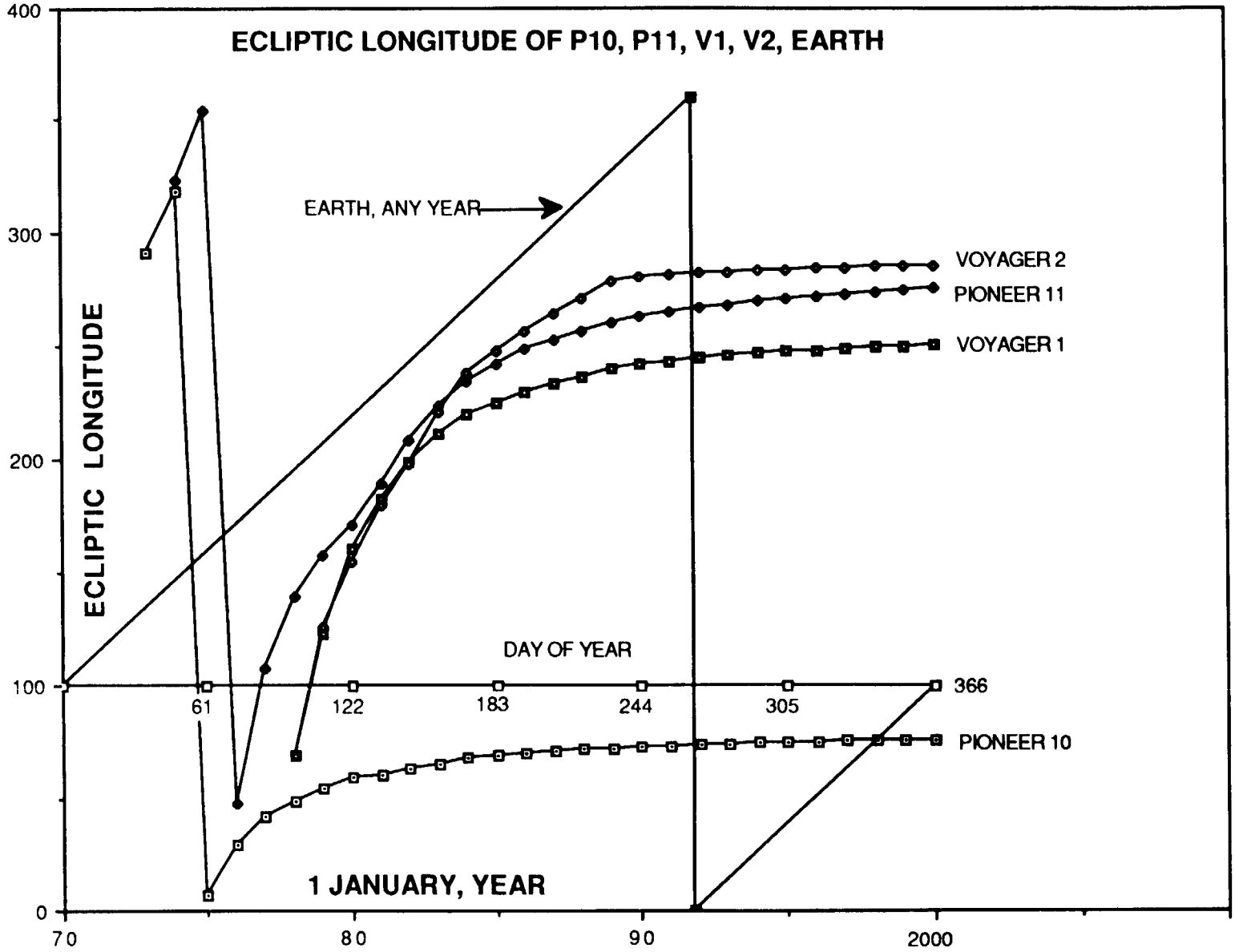


Figure 3. Ecliptic Longitudes of Pioneer 10, Pioneer 11, Voyager 1, and Voyager 2

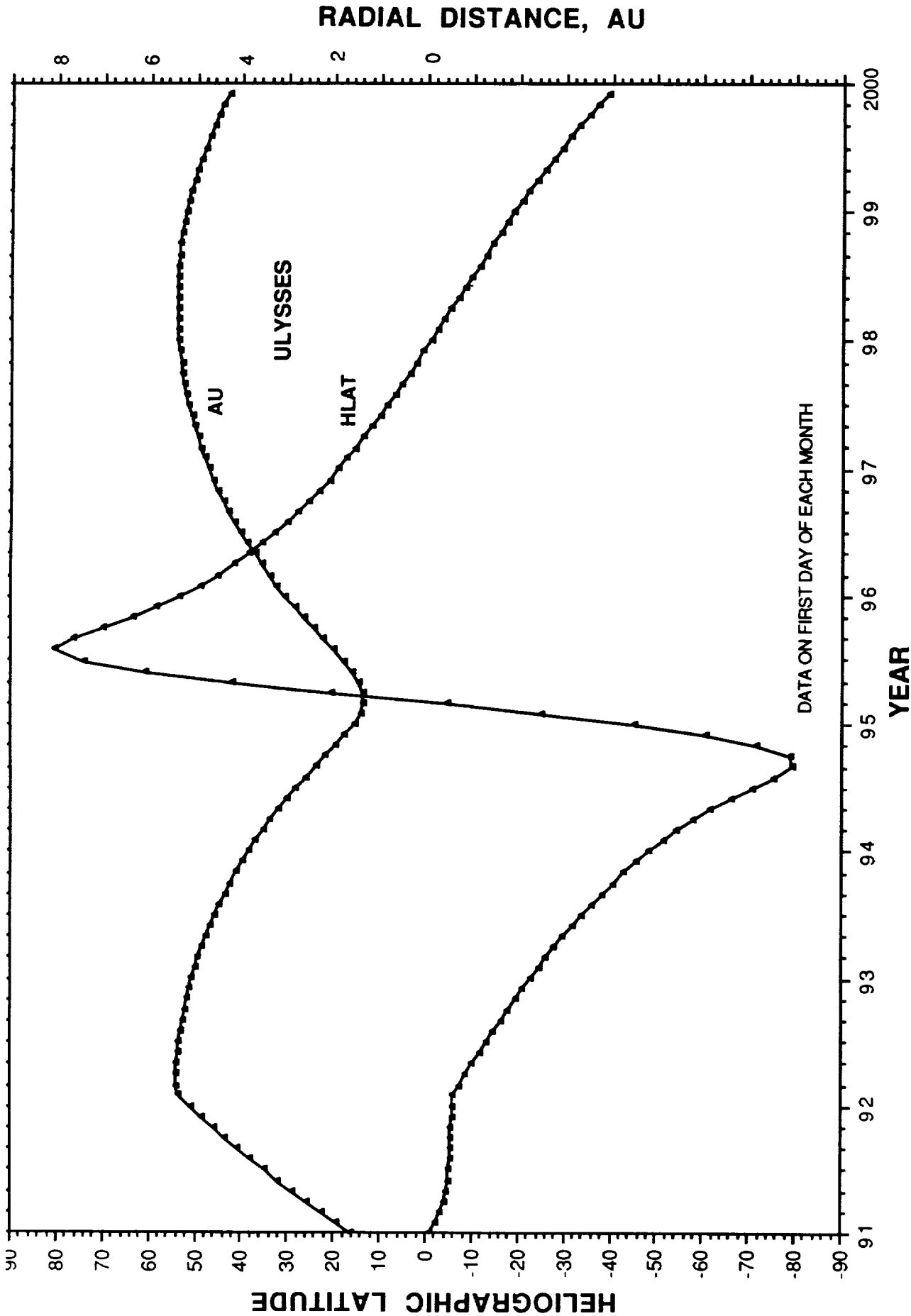


Figure 4. Radial Distance and Heliographic Latitude of Ulysses from Launch Through 1999

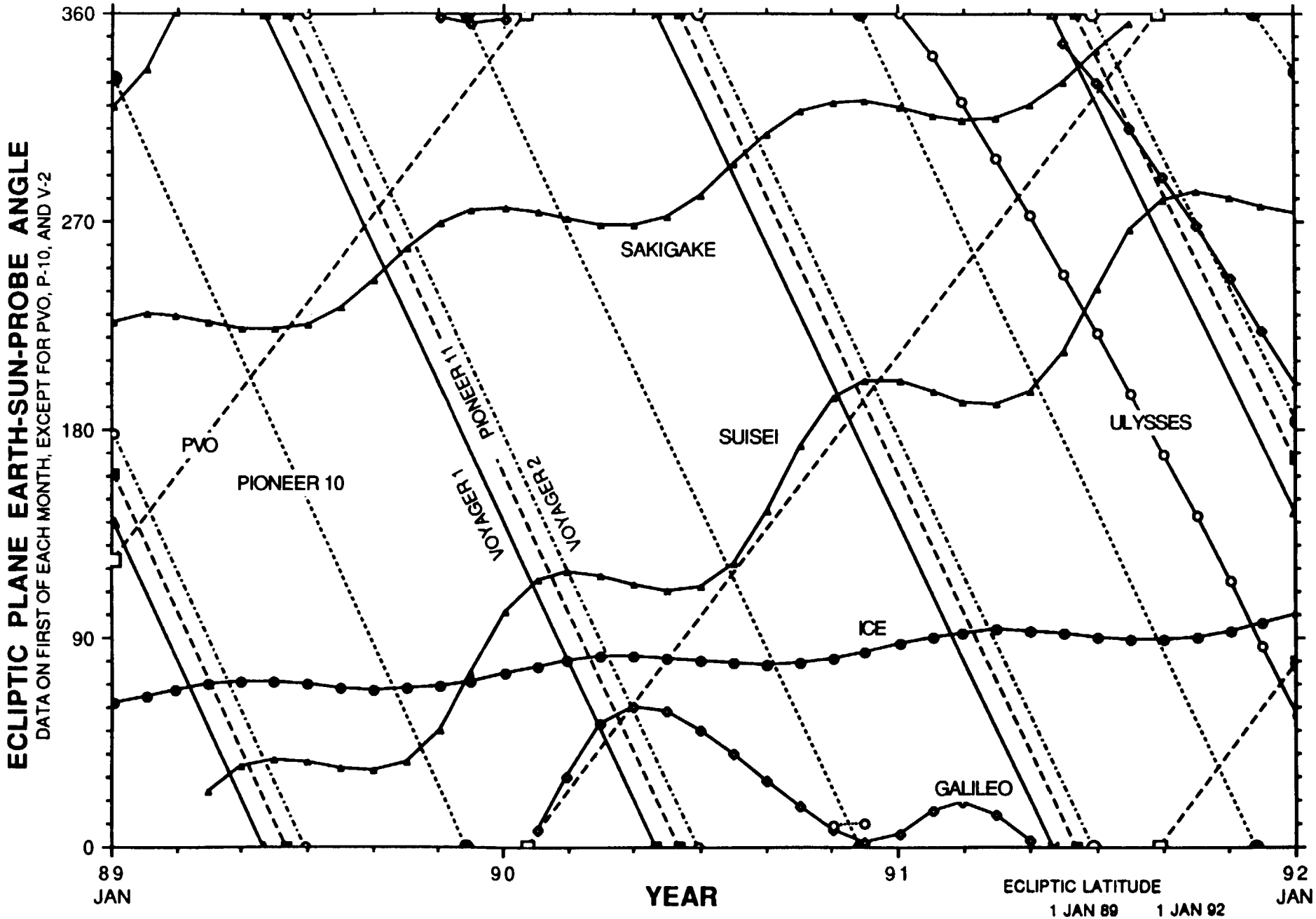


Figure 5. Earth-Sun-Probe Angles

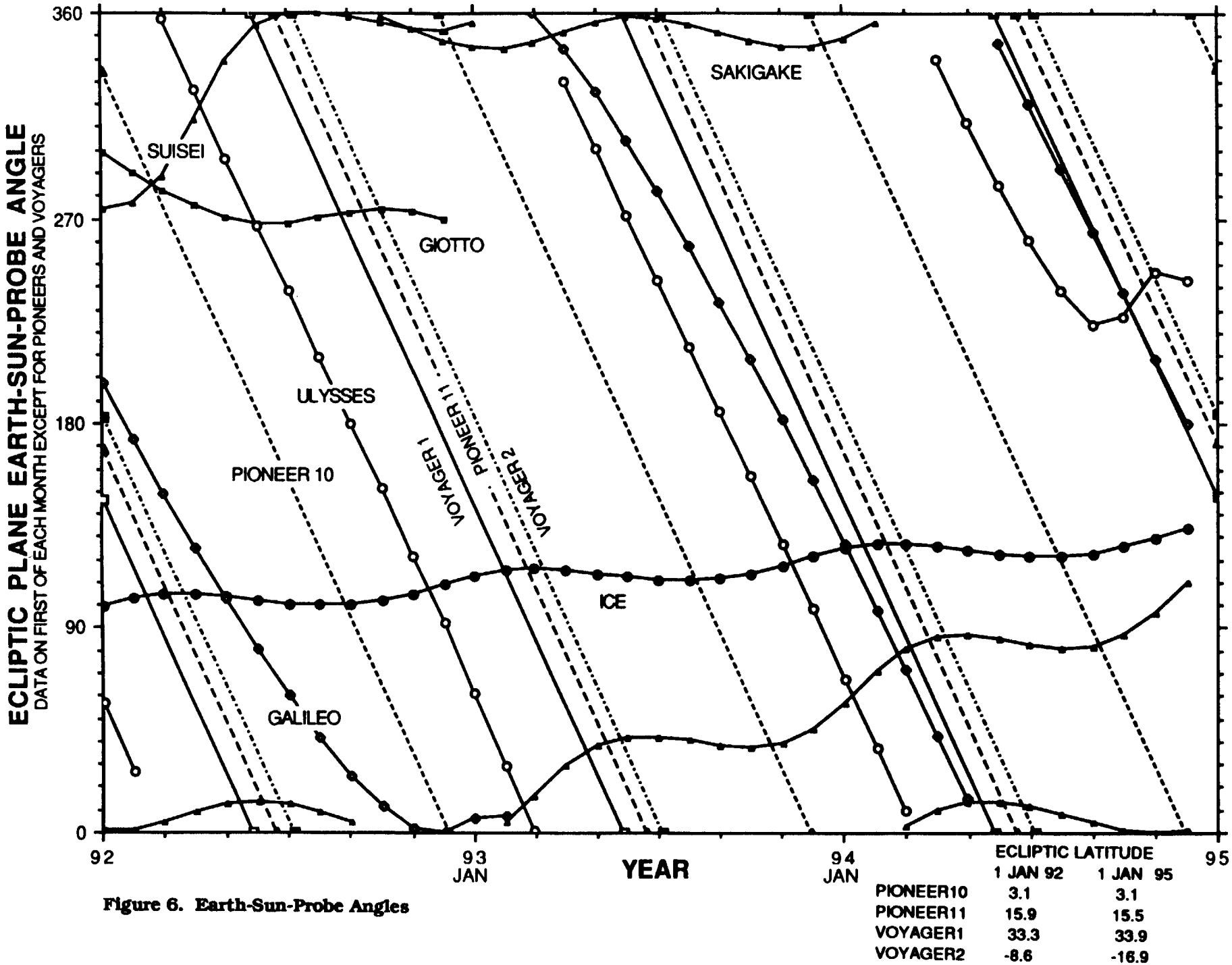


Figure 6. Earth-Sun-Probe Angles

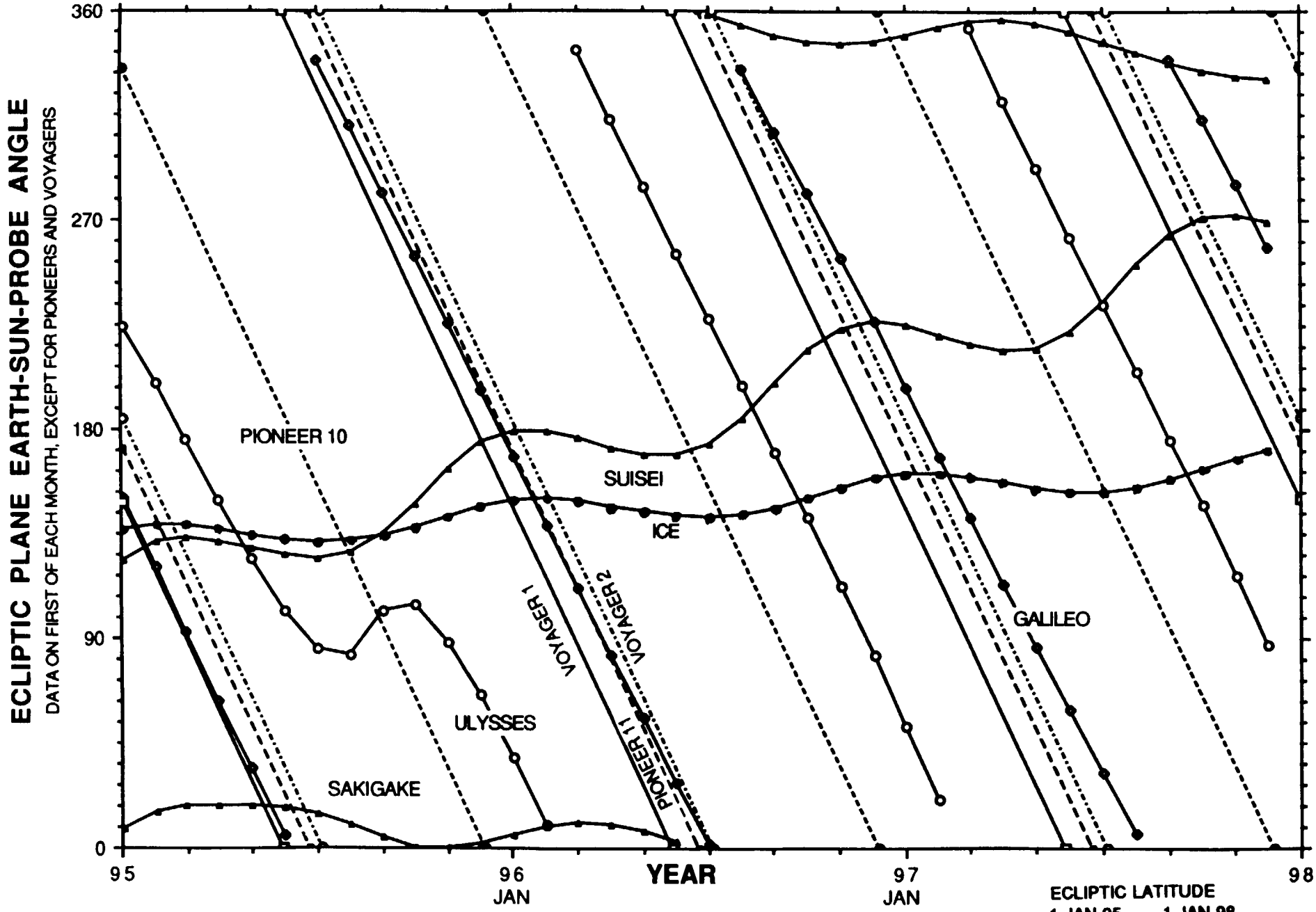


Figure 7. Earth-Sun-Probe Angles

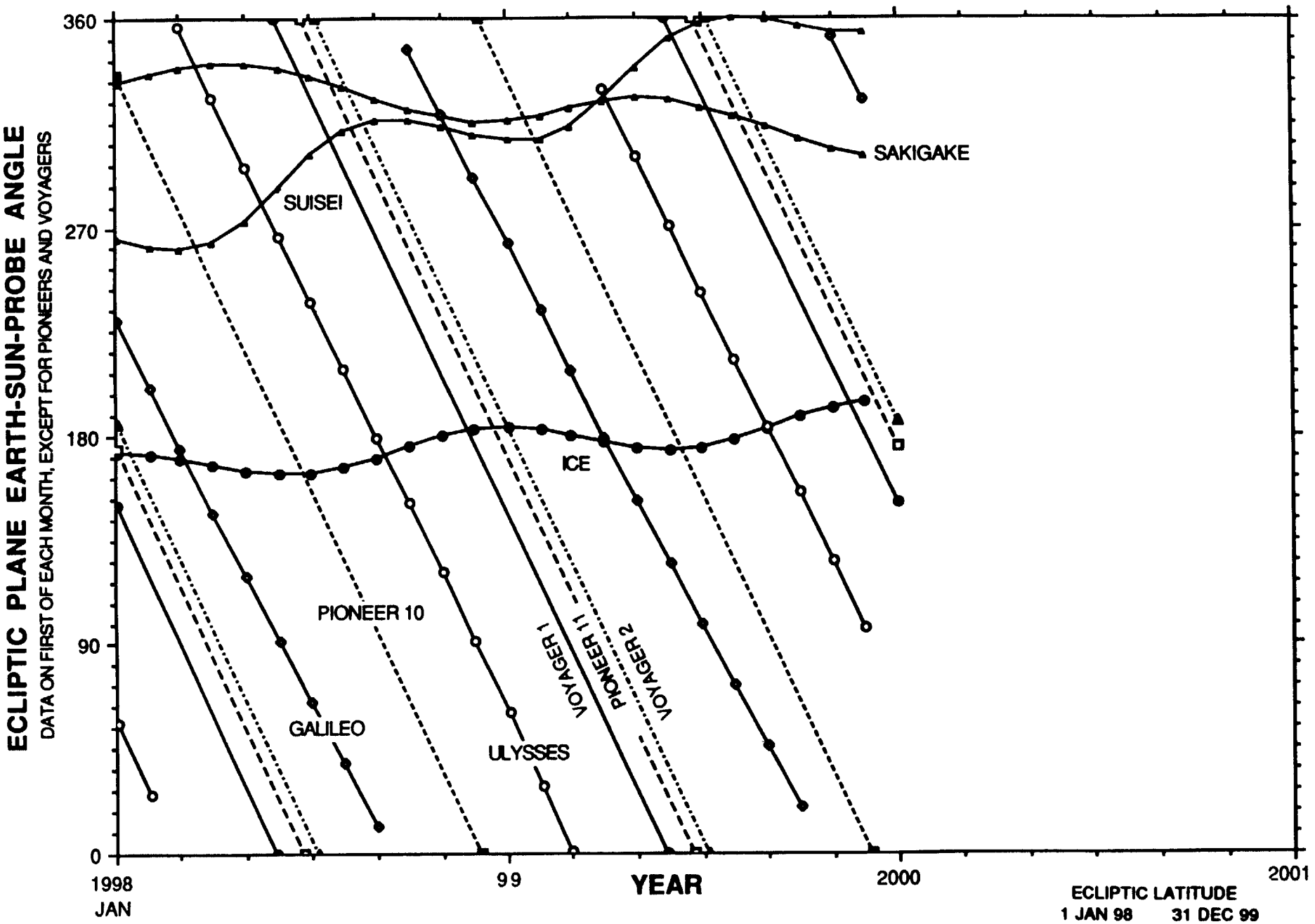
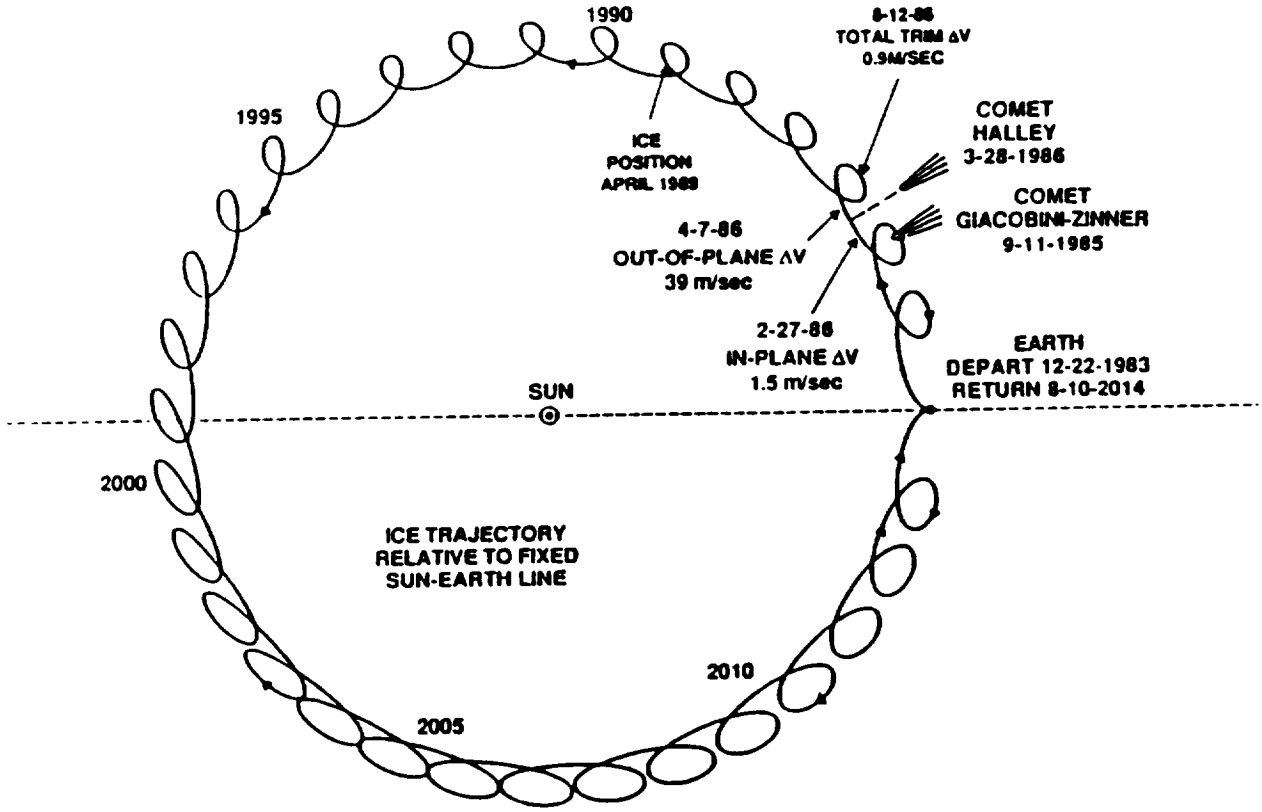


Figure 8. Earth-Sun-Probe Angles

ECLIPTIC LATITUDE	1 JAN 98	31 DEC 99
PIONEER10	3.0	3.0
PIONEER11	15.2	15.0
VOYAGER1	34.2	34.4
VOYAGER2	-22.2	-24.8



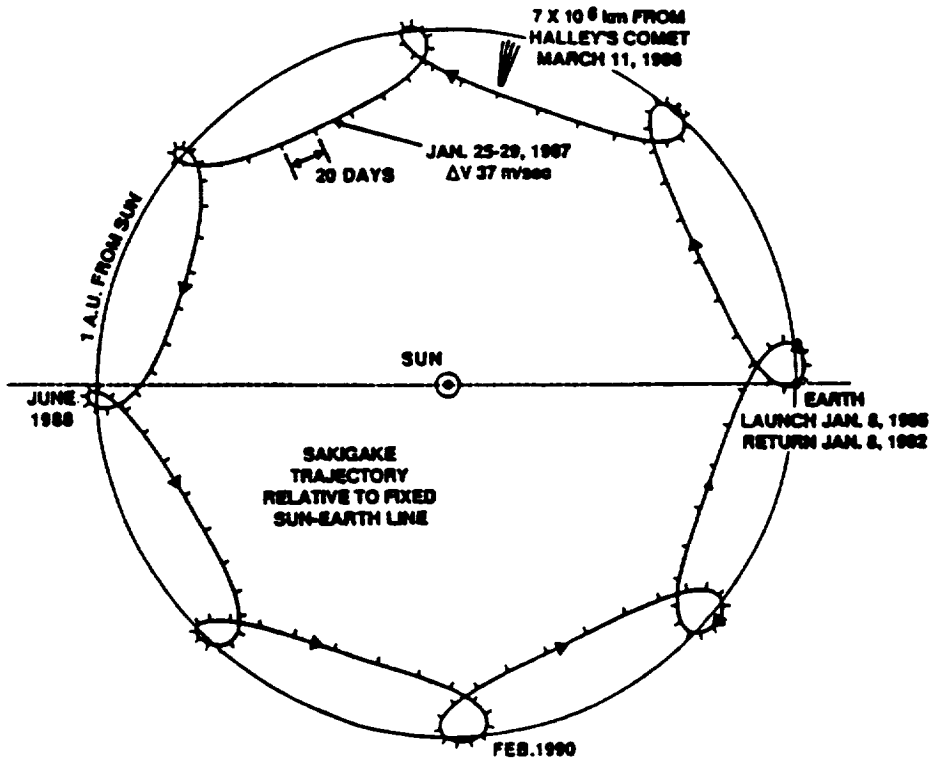
The ICE Earth-return trajectory (1983 to 2014) plotted relative to a fixed Sun-Earth line. Time interval between departure and return lunar swingbys is 11,189 days, or 30.634 years

Start and End Dates/Durations:

PHASE	DATES	DURATION
Transfer trajectory to halo insertion	8-12-78 to 11-20-78	100 days
Halo Orbit Phase	11-20-78 to 9-1-82	3 years, 9 month
Extended Mission	9-1-82 to 12-22-83	1 year, 3.7 months
Comet Intercept. Mission	12-22-83 to 9-11-85	1 year, 8.7 months
Heliocentric Cruise	9-11-85 to present	Open ended

SOURCE: Adapted from material in *Report of the STP Project of the IACG, Handbook on Trajectories, Mission Design, and Operations—Interim Version*, Computer Sciences Corporation, September 1989.

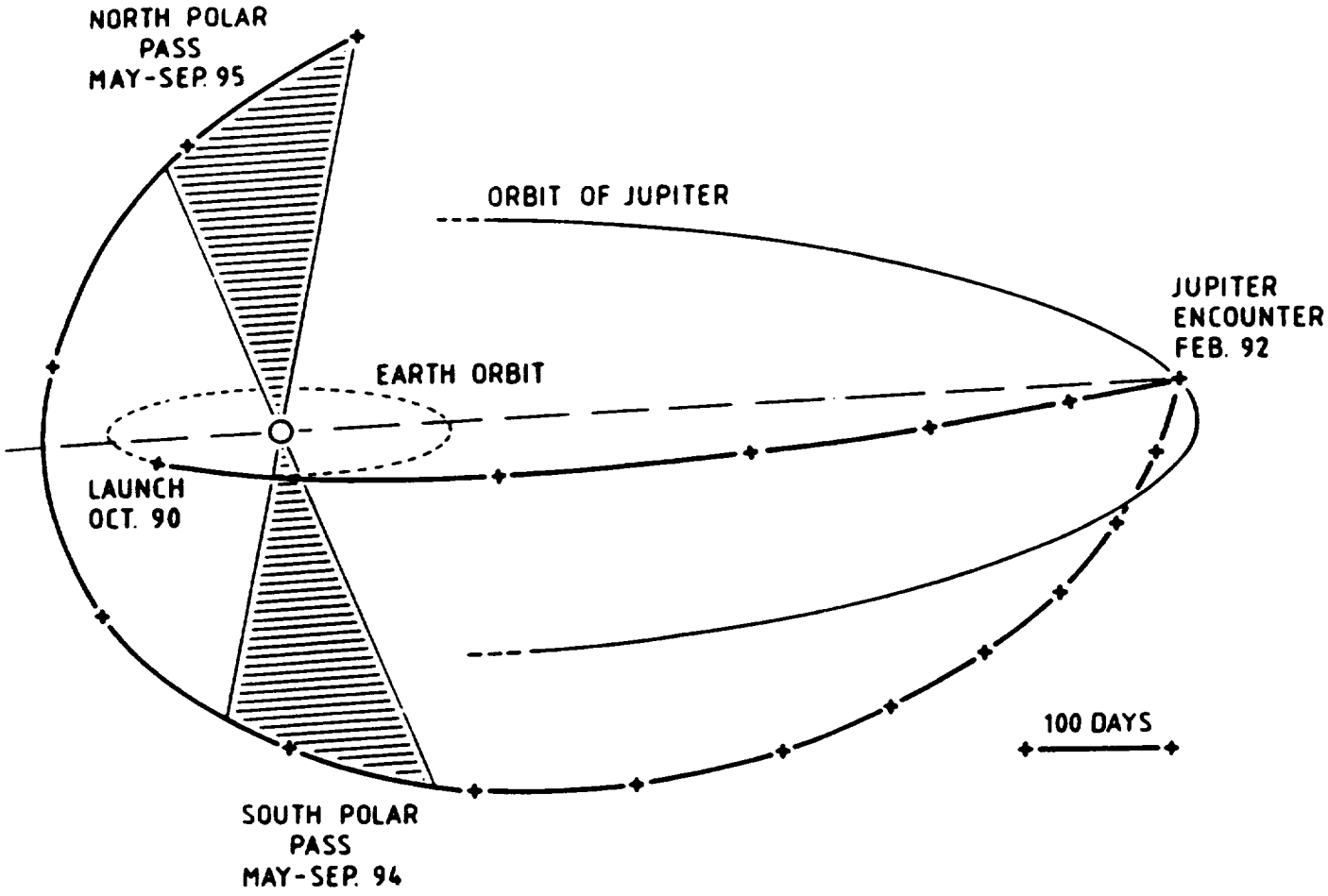
Figure 9. Earth-Sun-Probe Angle of ICE



Sakigake Earth-Return Trajectory, 1985 to 1992

SOURCE: Adapted from material in *Report of the STP Project of the IACG, Handbook on Trajectories, Mission Design, and Operations—Interim Version*, Computer Sciences Corporation, September 1989.

Figure 10. Earth-Sun-Probe Angle of Sakigake



Typical Ulysses Spacecraft Trajectory Viewed From 15 Deg Above the Ecliptic Plane

SOURCE: Adapted from material in *Report of the STP Project of the IACG, Handbook on Trajectories, Mission Design, and Operations—Interim Version*, Computer Sciences Corporation, September 1989.

Figure 11. A Three Dimensional Sketch of the Ulysses Trajectory